

# SAME-SIGN ELECTROWEAK CHARGED PARTICLE PRODUCTION AT LHC

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- SUSY motivation
- MSSM charginos: signal & bkg
- alternative models
- discriminating between models

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## Motivation

If candidate SUSY is discovered (would happen early in run), need to measure couplings, spins, incl. Majorana nature of inos.

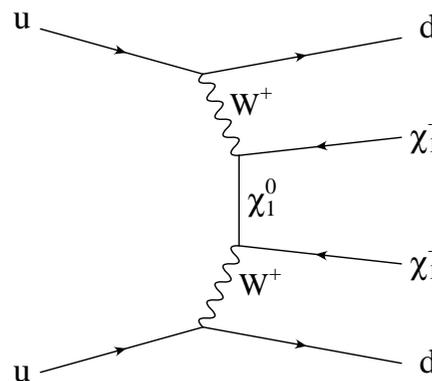
Gluginos: established techniques; weak inos: no techniques!

[Barr (2004); + Smillie, Webber (2005); Datta et al. (2005); Alves, Eboli, Plehn (2006); ...]

Idea: use same-sign chargino production via weak boson fusion

[Cho, Hagiwara, Kanzaki, Plehn, DR, Stelzer (2006)]

Observation proves at least one neutralino is Majorana



Also provides EW measurement input to FITTINO/SFITTER  
SUSY Lagrangian extraction programs.

[Lafaye, Plehn, D. Zerwas (2004); Bechtle, Desch, Wienemann (2004)]

## Electroweak same-sign chargino signal (weak boson fusion)

Recall signal sizes from 2006 study [Cho et al., PRD]:

SPS	1a	1b	2	3	4	5	6	7	8	9
$\chi_1^+ \chi_1^+$	0.93	0.22	0.48	0.23	0.51	0.57	0.067	0.077	0.31	0.88
$\chi_1^- \chi_1^-$	0.28	0.056	0.13	0.058	0.14	0.16	0.017	0.020	0.083	0.25

$\mathcal{O}(1)$  fb at some points is quite promising

(we can dig out other unique fb-sized xsecs at (S)LHC)

- for simplicity, examine long-lived chargino case: SPS9 (AMSB)

$$m_{\tilde{\chi}_1^\pm} = 197 \text{ GeV}$$

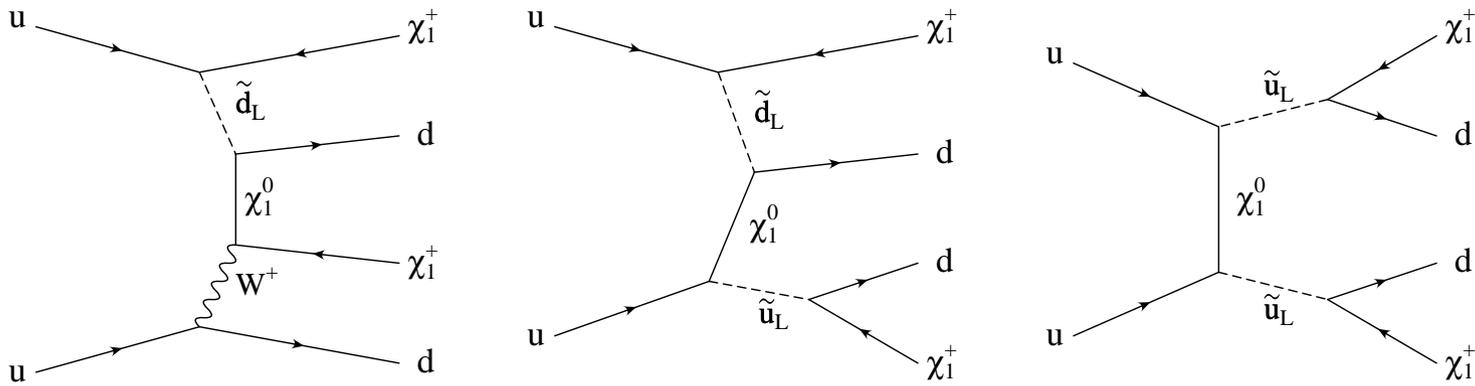
→ trigger on forward tagging jets or charginos themselves

→ we'll show how to handle bkg in prompt-decay case

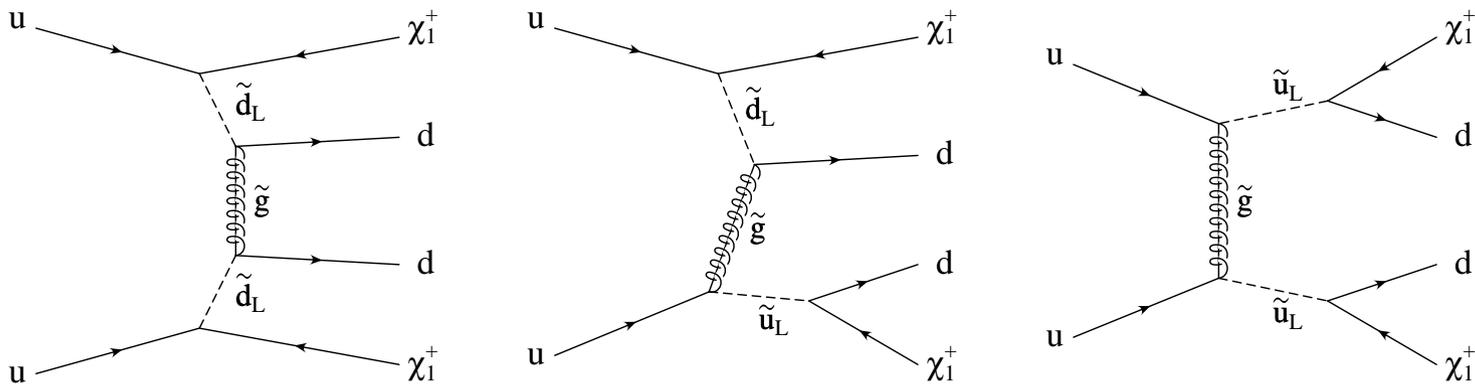
# SUSY backgrounds

→ for long-lived charginos, only SUSY backgrounds matter

## ① SUSY EW non-WBF (mostly squark poles)



## ② SUSY QCD (mostly squark poles)



## Step 1: basic WBF and optional pole cuts

WBF cuts established from extensive LHC Higgs pheno

$$\text{CutA :} \quad p_T(j) > 20 \text{ GeV}, \quad |\eta(j)| < 4.5$$
$$p_T(\tilde{\chi}_1^\pm) > 10 \text{ GeV}, \quad |\eta(\tilde{\chi}_1^\pm)| < 2.5$$

$$\text{CutB :} \quad |\eta(j_1) - \eta(j_2)| > 3.0, \quad \eta(j_{min}) < \eta_{\tilde{\chi}_1^\pm} < \eta(j_{max})$$

$$\text{CutC :} \quad |M(j, \tilde{\chi}_1^\pm) - M_{\tilde{u}}| > 30(50) \text{ GeV}$$

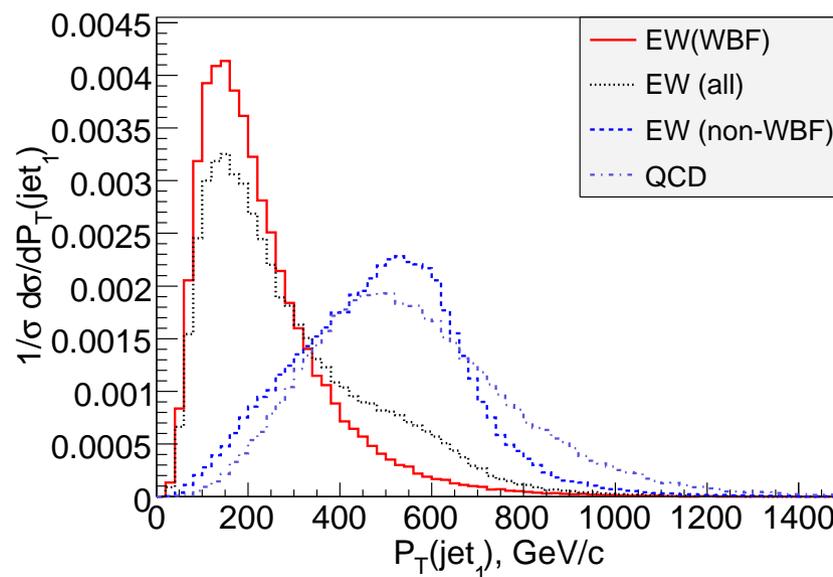
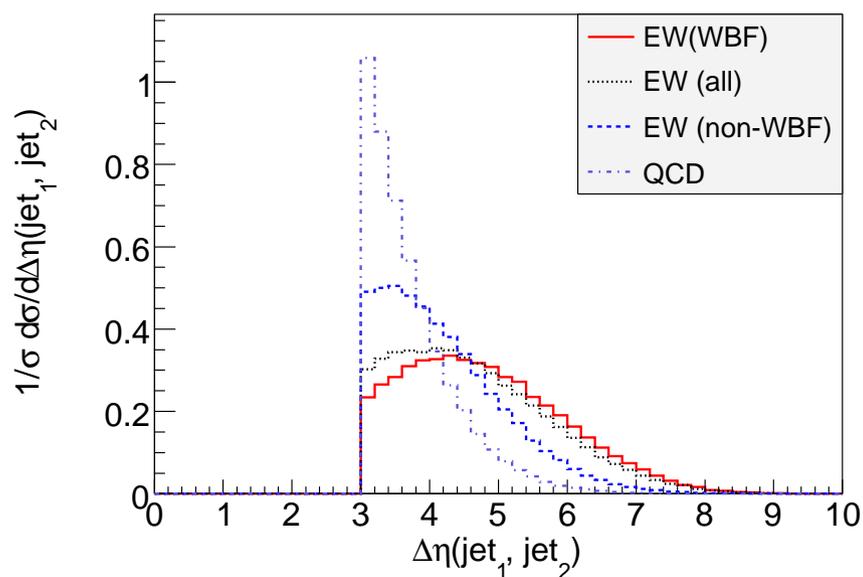
cuts	A & B	C-1	C-2
WBF	0.83 fb	0.77 fb	0.72 fb
EW non-WBF	0.26 fb	41 ab	23 ab
QCD	0.26 fb	8.7 ab	3.7 ab
<b>S/B</b>	<b>1.6/1</b>	<b>15/1</b>	<b>27/1</b>

**Piece of cake:** WBF cuts remove almost all squark decays  
( $S/B > 1/1$  even without pole cuts)

## Step 2: kinematic distributions

But what if charginos decay promptly?

Check (normalized) jet distributions for discriminating power:



WBF signal:  $p_T(j) \sim M_W$

EW/QCD  $\tilde{q}$  bkg:  $p_T(j) \sim m_{\tilde{q}}$

► jet dist'ns make technique independent of chargino decays!

# Distinguishing models

Observing signal doesn't prove chargino character!

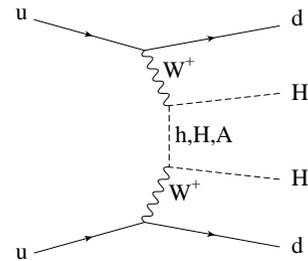
– are the long-lived charged particles really even fermions?

→ reasonable alternatives are scalars and vectors

(could be long-lived from discrete parity or mass degen'cy)

① **Scalar toy model: MSSM 2HDM** (could use general 2HDM)

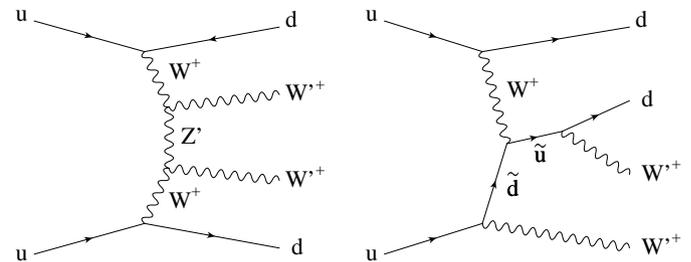
→ same-sign charged Higgs production via WBF



② **Vector toy model:  $Z' / W' / H' / f'$  based on LH/T-parity model**

→ all couplings set to SM strength

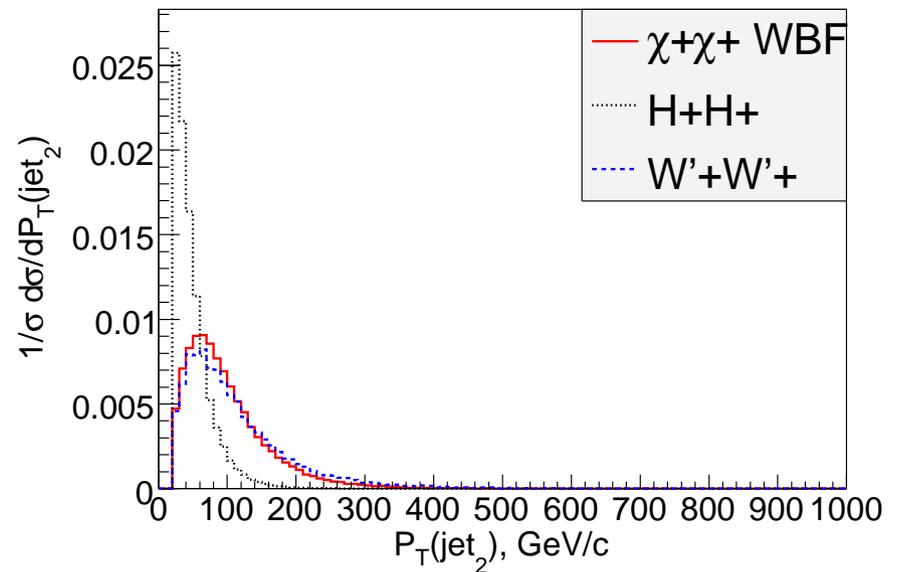
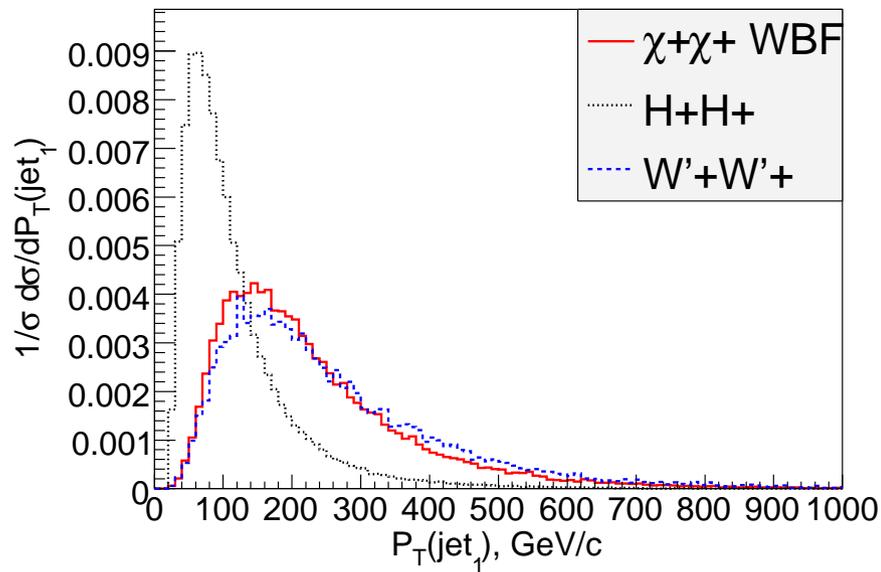
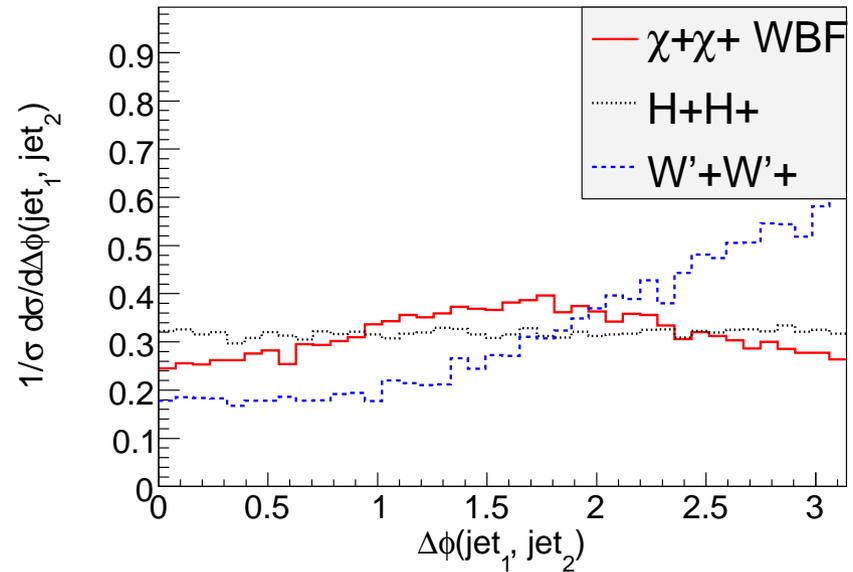
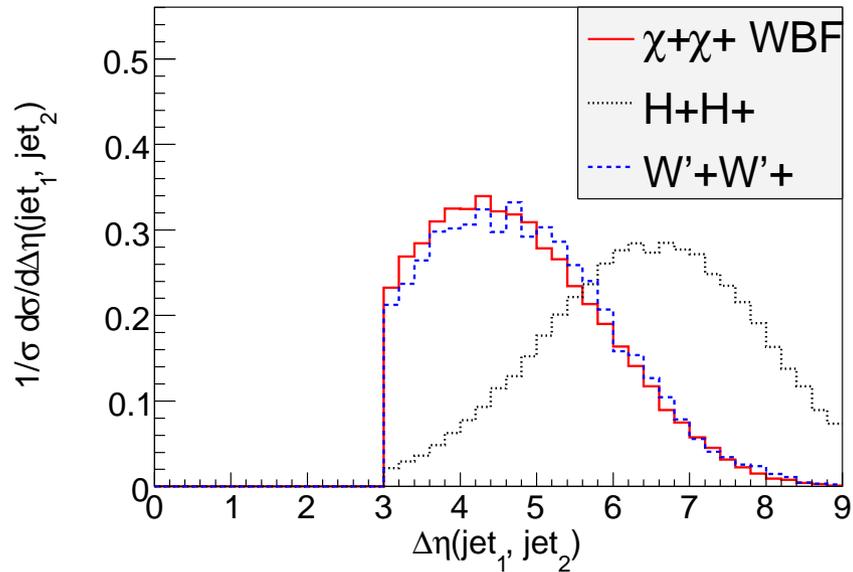
( $V' f f', V V' V', V V' H'$ )



● all model xsecs normalized to MSSM SPS9

●  $m_{\tilde{\chi}_1^\pm} = m_{H^\pm} = m_{V'^\pm} = 197 \text{ GeV}$

# Distinguishing models – distributions

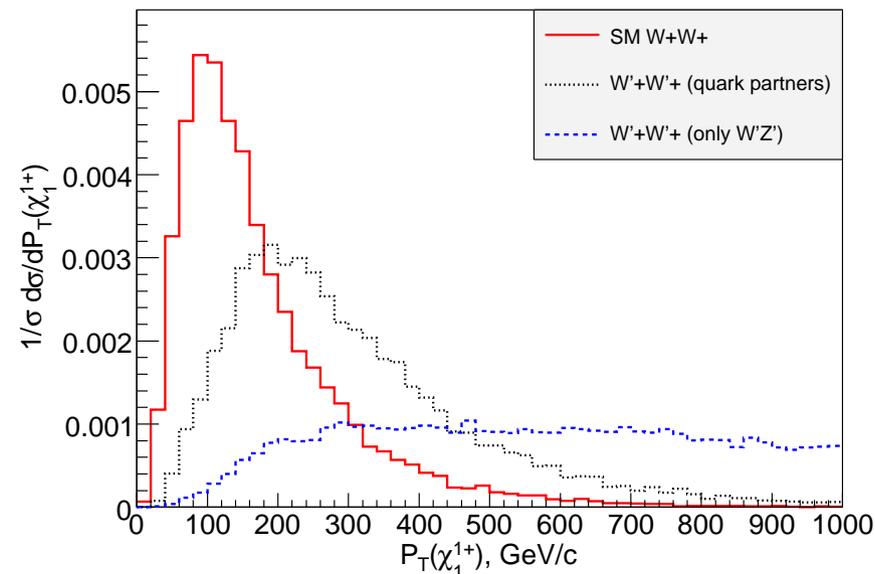
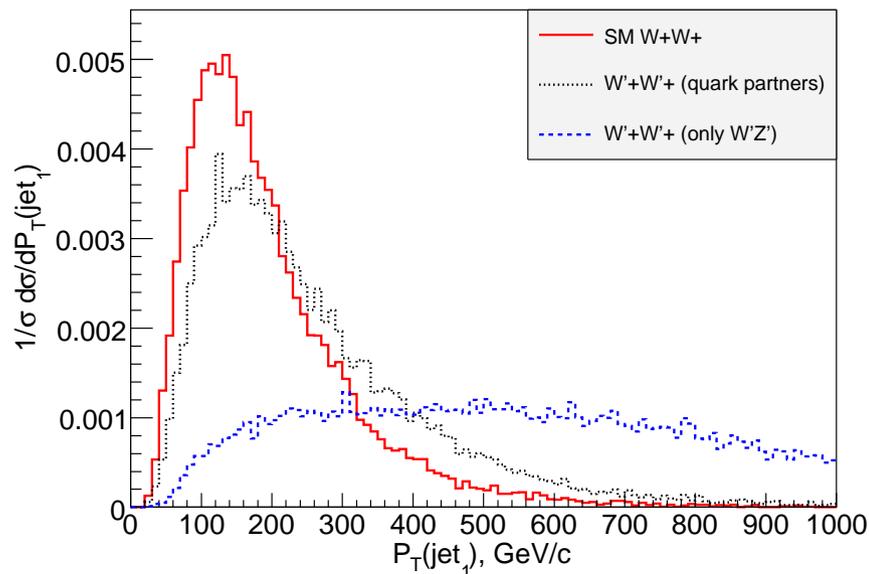
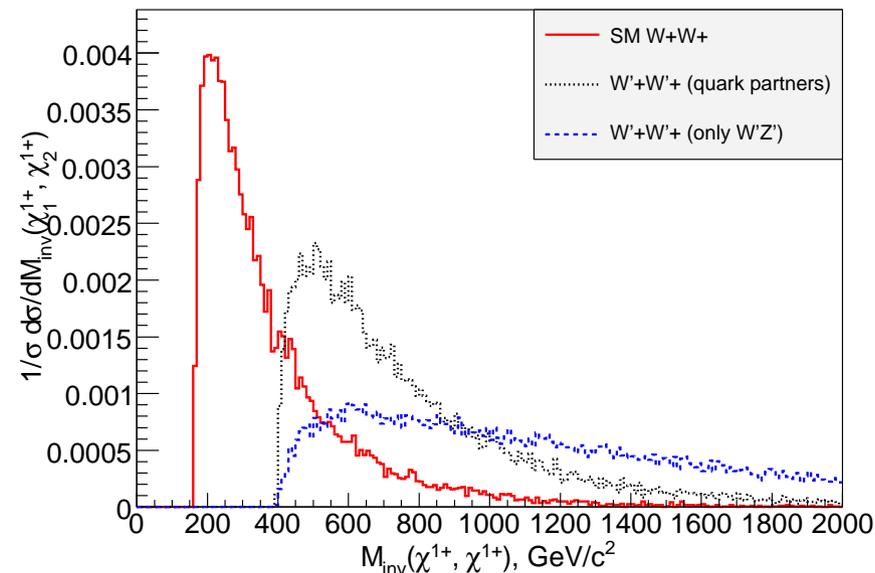
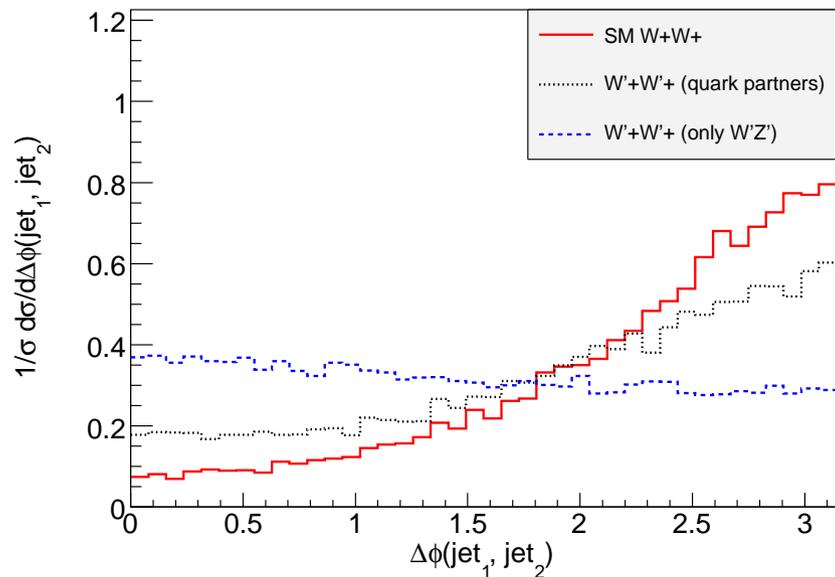


scalar  $\sim W_L$  but fermion/vector  $\sim W_T$

►  $\Delta\phi_{jj}$  super-important, as in WBF Higgs physics

# Vector model: note on unitarity

Unitarity violation w/o gauge canc'ln from Brem. diagrams (need  $f'$ )!



→ bogus distributions, espec. at high  $p_T$  or  $M$

## CONCLUSIONS

- If candidate SUSY obs'vd @ LHC, need to meas. spins, etc.
  - WBF same-sign chargino (wino-like) small, but distinct
  - SUSY backgrounds from heavy squarks suppressable
  - Technique depends only on tagging jets, not long-lived charged particles v. decays
  - Discrimination from other models easy with jet dist'ns
  - Would satisfy Joe Lykken's request for LHC evidence that we're guarantee good physics at ILC
- ▶ paper in draft, should appear soon